NISTTech

The Microfluidic Palette: Generation of Multiple Chemical Gradients within a Microfluidic Chamber

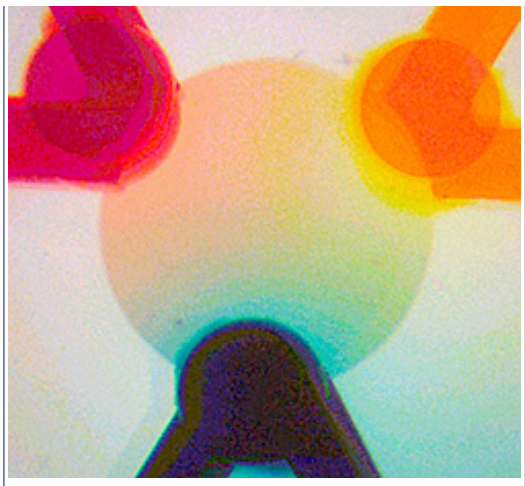
Study Biological Processes at the Cellular Level Using Microfluidics

Description

Generates multiple chemical gradients simultaneously within a microfluidic chamber. Enables the study of simultaneous diffusion and mixing of drugs or chemicals in applications where molecular gradients play an important role. With more than three ports to introduce fluids, this device eliminates convection in chemical/molecular transport to allow controlled and stable diffusion patterns to be examined. Diffusion gradients permit chemical molecules to move in and out of the cells naturally and eliminate the risk of shear stresses, commonly produced by currents, which could cause the cells to rupture or behave abnormally. An independent gradient forms for each substance that remains constant as long as flow into the system does not change. A blend of concentrations occurs where the gradients meet, and the combination in any single location within the blend is distinctly different from all other locations.

Images

The mixing area is the pin-sized chamber bordered by three holes in the center of the top layer. (Credit: G. Cooksey, NIST)



For each of the three dyes injected into the NIST microfluidic palette, an independent gradient forms that remains constant as long as flow into the system does not change. Overlapping the three gradients results in a blend of dye concentrations, but the combination of colors in any single location is distinctly different from all others location. (Credit: J. Atencia, NIST)

Credit: NIST

Applications

- **Cancer therapies**
  Personalized chemotherapy screening for optimal drug combination by examining specific cancer cell cultures exposed to several drug combinations. In-vivo chemical surgery by drug delivery by diffusion without introducing added liquid volume.
- **Medical and environmental research**
  Study chemotaxis, a biological phenomenon that plays a role in the spread of cancer (metastasis), wound healing, infection and ocean carbon cycling.
- **Protein crystallography**

Screen proteins with several chemical combinations and actively grow bigger and better crystals without disturbing convective flows.

Advantages

- **In-vivo research of multiple chemical interactions**
  Allows setup and monitoring of combinatorial experiments in a microfluidic chamber instead of vials, permitting sampling of continuous gradients.
- **Dynamic technique for microfluidic research**
  Extends existing microfluidic techniques (limited to studying static diffusion between two chemicals) to dynamically-controlled diffusion between three or more chemicals.
- **Eliminates convective flow**
  Eliminates disturbing and disruptive convective flows.

Abstract

The invention consists in a microfluidic device that generates multiple chemical gradients simultaneously within a microfluidic chamber. The chemical gradients are generated without convection, only by diffusion, and they can be maintained over long periods of time, or be modified dynamically.

Description of the microfluidic device:

The device consists of a main microfluidic chamber where there is no convection (no flow movement) and where mixing is done by diffusion. The chamber is accessed by "convection-diffusion units". A convection-diffusion unit consists of a microchannel that has matched flow at its inlet and outlet; thus, even if the microchannel has an opening to the microfluidic chamber, all the liquid that is introduced through the inlet has to come out through the outlet (conservation of mass) making it impossible to get into the chamber except by diffusion. If the inlet and outlet of each convection-diffusion unit were not exactly matched, difference in pressure among microchannels would generate convection through the chamber ruining the diffusion-only premise inside the microfluidic chamber.

The convection-diffusion units decouple convection in the microchannels from diffusion in the chamber. Therefore, if a solution of a drug is introduced through inlet 1 and retrieved through outlet 1, the concentration of this drug at the opening 1 to the chamber will be the same as at the channel. If only buffer flows through channels 2 and 3, the concentration of the drug at the openings 2 and 3 necessarily will be zero. Thus, in the microfluidic chamber, opening 1 works as a diffusive source of the drug, while opening 2 and 3 work as sinks, and all the space in between (after some transient time) will have a static gradient in concentration of the drug.

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Citations

1. J. Atencia, J. Morrow and L.E. Locascio. The microfluidic palette: A diffusive gradient generator with spatio-temporal control. *Lab on a Chip*. Posted online June 22, 2009.

Related Items

- 'Microfluidic Palette' May Paint Clearer Picture of Biological Processes

References

- U.S. Patent Application #20090311737
- Docket: 08-013

Status of Availability

This invention is available for licensing.

Last Modified: 10/19/2010